Efficiency of Currently Used Anthelmintics in Bovine Practice **

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In selecting an anthelmintic the veterinarian must concern himself with the several attributes within which the most desirable chemical can be defined. These attributes are the therapeutic index, ease of administration, presence or absence of residues, efficiency, and cost. It is quite obvious that no particular anthelmintic is superior in all characteristics, since if one were it would soon be the only marketable product. The primary purpose of this paper is to examine one of these characteristics, namely efficiency, in relation to the currently available anthelmintics for cattle.

There are many anthelmintics such as copper sulfate and carbon tetrachloride, as well as combinations of inorganic and organic chemicals available which will not be discussed in detail in this presentation. Those compounds which will receive more detailed evaluation are: phenothiazine, thiabendazole, coumaphos, levamisole, and haloxon.

In order that we may have a common basis for discussion it will be well to briefly examine the flow pattern of our cattle industry. At this point the writer apologizes to the dairy practitioners in that he has centered his presentation on the beef industry. It is believed, however, that the "fall-out" will be relevant to the dairy industry.

The starting point in the beef industry is the cow-calf producer. Within this production unit are mature cows of varying ages, replacement heifers retained from calfhood, the annual marketable steer and heifer calves, the herd bulls, and replacement heifers, cows, and bulls purchased from other producers. This basic production unit, at least for the present time, is largely maintained on less costly marginal land where native and/or improved rangeland and pasture forage is the source of primary nutrients. Such production units even though having much in common may be vastly different in terms of environment and management. Such differences grossly influence the helminth problems, relative to the presence or absence of disease, apparent anthelmintic efficiency, and ease of anthelmintic administration. For the moment one can conclude that within the cow-calf production unit the potential for helminth disease is present at all times. The particular helminth diseases which may occur are, however, limited or extended by management and by ecological requirements of specific helminths.

The same general statements apply to the stocker or backgrounding operation wherein pasture or rangeland is used as a source of nutrients. Helminth control is more amenable on stocker rangelands and pasture since for the most part one is working with cattle of similar age, sex, and management requirements.

Within the feedlot, i.e., drylot, the problem of helminth control is markedly simplified in that with rare exception the infection cycle does not function at a rate commensurate with the production of disease.

With this brief view of the beef industry let us now consider the helminths which are of primary importance to the cattle industry. Within the United States we are quite fortunate that helminth parasites of major economic importance in cattle are limited to the gastrointestinal tract, its associated glandular organs, and the respiratory tract. In Table 1 those species of major concern are listed. It should be understood that this list is a presentation of the writer's opinion and that others might not fully agree with that opinion!

TABLE I

HELMINTHS OF MAJOR ECONOMIC IMPORTANCE IN CATTLE (USA)

Abomasum	
	Haemonchus contortus
	Ostertagia ostertagi
	Trichostrongylus axei
Small Intestine	
	Cooperia spp.
	Trichostrongylus spp.
	Bunostomum phlebotomum
Large Intestine and Cecum	
	Oesophagostomum radiatum
Lungs	
	Dictyocaulus viviparus
Liver	
	Fasciola hepatica

In Table 1 no consideration is given as to geographical region and associated ecological conditions which may play a major role in

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determining the species which are responsible for economic losses. While mixed infections of several species are the rule, in almost all instances only one or two species are of primary importance at any one time or place. Table 2 presents the species which are of most importance in the central valley and Sierra-Nevada mountains of northern California. If one were to take still smaller geographical limits within this region, the list in Table 2 would be even more abbreviated.

TABLE 2

HELMINTHS OF MAJOR ECONOMIC IMPORTANCE IN NORTHERN CALIFORNIA CATTLE

Abomasum	
	Ostertagia ostertagi
	Trichostrongylus axei
Small Intestine	
	Cooperia spp.
Large Intestine and Cecum	
	Oesophagostomum radiatum (rarely)
Lungs	
	Dictyocaulus viviparus
Liver	
	Fasciola hepatica

The purpose for considering this particular aspect of parasitology is to point out that a compound which may be of high efficiency when used in California, may have low efficiency against a different target species in other regions. For the most part, the practitioner is inclined to select the anthelmintic of broadest spectrum; if he considered the cost of an anthelmintic with a narrower spectrum which covered the species with which he is concerned, he might do well to select the anthelmintic with the narrower spectrum.

The lists presented in Tables 1 and 2 do not give consideration as to whether the species are important in their larval stages as well as in their adult stages. This is to ask, is the efficacy of a particular anthelmintic against immature worms of importance in the evaluation of an anthelmintic? Table 3 presents the writer's opinion as to those species in which anthelmintic efficacy against

TABLE 3

SPECIES OF HELMINTHS HAVING IMMATURE LARVAL STAGES OF ANTHELMINTIC SIGNIFICANCE

Abomasum	
	Ostertagia ostertagi
Small Intestine	
	Bunostomum phlebotomum
Large Intestine	
	Oesophagostomum radiatum
Lungs	
	Dictyocaulus viviparus
Liver	
	Fasciola hepatica

immature stages would be desirable. At the risk of heated contradiction I will candidly state that in my opinion there now exists evidence of efficacy against only one of these species, namely *Dictyocaulus vivipara*, which would significantly influence my selection of an anthelmintic now available in the United States.

Very often the writer has been asked his opinion of the efficiency of a particular anthelmintic against a particular species of helminth in cattle. More commonly, he is asked his opinion of a particular anthelmintic against worms in cattle. In both instances the questioner is usually referring to specific cattle, under specific conditions, and infected with specific worms. The writer is usually somewhat evasive in his answer. Some of the basis for this evasiveness is apparent from the foregoing, a still greater part of the reason is to be found in the limitations of the methods used for the evaluation of anthelmintic efficiency. Because of this, a brief discussion of such methods is in order. Table 4 lists those methods which are most often used.

TABLE 4

METHODS OF ANTHELMINTIC EVALUATION IN CATTLE

I.	Performance Tests
II.	Parasite Egg Production
III.	Controlled Anthelmintic Test
	A. Experimental Infection
	B. Natural Infection
IV.	Critical Anthelmintic Test
	A. Experimental Infection
	B. Natural Infection

There are two common methods by which the producer, practicing veterinarian, or research veterinarian may choose to measure efficiency. The first of these is by means of the performance test. In conducting this test a group of animals is separated into two groups, one of which is treated with the anthelmintic, and one which is untreated or to which a placebo is administered. Weight gain, feed conversion, or some other measure of performance is determined and the anthelmintic termed efficient or not efficient. Viewing this test from the variability of the parasite burden only, the pitfalls of such a test can be shown. Assume the cattle are infected with *Ostertagia ostertagi* and that some theoretical number such as 30,000 worms are necessary to produce decreased performance. If the experimental cattle harbored 40,000 worms and the efficiency of the anthelmintic was 90%, there would be 4,000 worms remaining after treatment and the anthelmintic would be termed effective. A similar result might be obtained if the cattle initially harbored 300,000 worms since 90% removal would leave 27,000, a lesser number than our critical 30,000. Now, supposing we utilized an anthelmintic with an efficiency of only 26%. In cattle harboring an initial 40,000 worms we might find it to be highly efficacious, but we would soon change our mind if we started with cattle harboring 40,539 worms. Theorizing further, if one received cattle harboring 29,999 worms (remember, these numbers are strictly theoretical and our entire premise grossly simplified) then one would conclude the best anthelmintic available was completely inefficient. In this instance a more probable conclusion would be that no anthelmintic was needed. In order to eliminate such vagaries one should utilize three groups of cattle, one untreated, one treated with the anthelmintic being evaluated, and one treated with a reference anthelmintic of established efficiency.

The second most used test at the practitioner level is the reduction in parasite egg counts (epg) and/or larval counts in feces. This test, if conducted properly, is useful, but again has distinct limitations. Phenothiazine is perhaps the best known, but certainly is not the only anthelmintic which may severely depress the epg without a corresponding vermicidal effect. Ruelene applied as a pour-on to the backs of calves may produce a 90-95% reduction in epg for periods as long as 6-8 weeks. In no case, to the author's knowledge, has an efficiency of greater than 60% against those helminths listed in Table 1 been *consistently* attained by topical application of systemic insecticides when measured by controlled or critical test. One should again note that if initial worm burdens are sufficiently low, this level of activity may be classed as highly efficient if measured by performance tests. Further, one must conclude that such a prolonged reduction in epg is highly efficient in terms of reduction in pasture contamination. Such problems can be partially eliminated by waiting a sufficient time after administration of the anthelmintic for parasite egg production to return to normal in the remaining worms. A period of 7-14 days with phenothiazine and other orally administered anthelmintics is usually sufficient. No such correction is feasible for topical compounds such as Ruelene. If a waiting period is utilized, one must consider the possibility that immature worms not removed by the anthelmintic may mature and begin to produce eggs.

A further problem in the epg reduction test may be found wherein two or more species of worms having disproportionate biotic potential and anthelmintic susceptibleness are present. If we have a 1:1 ratio of *Haemonchus contortus* (biotic potential of 5,000-10,000 eggs per day per female) and of *Ostertagia ostertagi* (biotic potential of 100-300 eggs per day per female) and the anthelmintic completely removes the *Ostertagia* without any action on *Haemonchus* the epg reduction would indicate an efficiency of only 2-5% when it was in actuality 100% against *Ostertagia*, 0% against *Haemonchus* and 50% against the total worm population. Conversely, if all *Haemonchus* were removed and there was no action on *Ostertagia* an efficiency of 95-98% would be recorded.

Corrections related to species may be partially made by culturing of feces before and after treatment and subsequently identifying the larvae. Such things as differential rates of development and the influence of anthelmintics on embryonation may limit the value of this procedure. Probably of most importance is that the practitioner be wary of any report of anthelmintic efficiency values based on the differentiation of nematode eggs in feces. The writer does not believe anyone can identify the individual strongylid and trichostrongylid ova in cattle feces with an acceptable degree of accuracy for this form of evaluation!

The tests from which most "definitive" values of efficiency are derived and in which the efficiency is expressed in terms of percentage removal of worms are the controlled and critical tests.

Either of these tests may utilize naturally exposed, or artificially infected cattle.

In conducting the controlled test, two groups of animals are set up in such a way that the mean and ranges of parasite species and counts are similar. One group is treated and then after some three to seven days all animals are autopsied. The worms are collected, counted, and identified. Efficiency is then obtained by comparing the number of worms remaining in the treated animals to that of the untreated group. One of the greatest problems with this method is the numbers of animals required to assure comparable initial worm numbers in both groups. This is particularly true when dealing with naturally acquired infections. Yet, in the writer's opinion, evaluation in natural infections is essential in that only then are such factors as worm age distribution, species interaction, strain differences, etc. of parasite species involved.

An additional problem in this method is the question of interpretation. For example, test groups of 10 calves may be used and a mean efficiency of 80% obtained. This may have originated from 100% removal in eight animals and 0% in two animals. Does this mean on a herd basis we can expect 100% removal of the particular parasite in 80% of the animals, and none in the remaining 20%? Does it mean in practice that the factor which resulted in the lack of activity in the two animals may be present in 100% of the animals in 20% of the herds and absent in 100% of 80% of the herds? It is the foregoing which in many instances may account for apparent drug failure or the need for repeated treatment.

Experimentally infected worm free calves are best used if one wishes to ascertain the efficacy against immature stages of specific parasites. The test is conducted in a similar manner except that the drug is administered to specific groups on specified days after infection. Time is allowed for the infection to become patent and the reduction (if present) in parasites in the treated group is presumed to be due to the action against the stage of development present at the time of treatment. An additional problem with experimental infections may be exemplified with *Cooperia spp.* and thiabendazole. In this instance the action of thiabendazole is very good against immature stages and the 3 gms/100 lb. body weight dosage is adequate. Against mature stages of this genus, thiabendazole is not so active, and if a high efficiency is required the 5 gm/100 lbs. body weight dosage must be used.

The so-called critical test involves the use of a single animal in which following the administration of the anthelmintic all worms passed in the feces are collected, identified and counted. The animal is then autopsied and the worms remaining are collected, identified, and counted. Efficiency is then calculated as 100 X (Passed + Retained)-Retained/(Passed + Retained).

This test, while theoretically the soundest, has inherent problems which in the writer's view make it less desirable than the controlled test. First, if sufficient repetitive tests are conducted it is subject to the same interpretive problems as the controlled test. In the case of large worms, and in particular those large worms in the large intestine, relatively accurate determination of number of worms passed in feces may be determined. In the case of the smaller trichostrongylids, however, one can never account for all of those passed, and as a result, the apparent anthelmintic efficacy obtained will be lower than that which actually occurred.

At this point in our discussion it will be well to allude to the status of parasitism in cattle as it presently exists. The writer and his colleagues have been involved in the evaluation and development of anthelmintics since early in the 1950's. At that time, and continuing into the early 1960's, parasitism in California cattle was rampant and experimental cattle for controlled tests with natural infections at levels producing "textbook" pictures of disease were available on a moment's notice. With the advent of thiabendazole, along with the tightening profit margins, and the educational programs of industry, universities, and the veterinary profession, the use of anthelmintics in cattle increased markedly and the pattern of parasitism has grossly changed. During the past winter, considerable time and monies were expended over a three month period before the writer successfully located cattle with sufficiently heavy worm burdens to assure valid measure of the efficiency of an anthelmintic in a controlled test. Since no startling geographical changes have occurred and management practices, other than the use of anthelmintics, have if anything been made more favorable to nematode parasites, one must attribute this very significant change in the status of parasitism to the use of anthelmintics. This alteration of the status of parasitism must influence many aspects of our practice and of our evaluation of anthelmintics. No longer are we dealing with the diagnostic problem as presented by the overly sick animal, but rather with the occult disease in which the results of therapy must be measured in terms of net dollars as obtained by increased performance rather than survival.

The practitioner must now give more regard to cost of an anthelmintic when making recommendations. Where alternative choices are available, he must give increasing concern to the frequency of administration, as well as the method, in order to reduce the total cost of nematode control. For example, parasite levels which do not interfere with production in brood cows may well cost $2.00-$5.00 per head in feedlot animals. Stocker cattle on rangeland may best be treated with a compound which reduces the worm burden by only 50% (if this is adequate to prevent reduced weight gains), at a cost of 10c per head in supplement, rather than with a compound having an efficiency of 90% costing 80c to $1.20 per head and requiring oral administration to individual animals.

In opening our discussion of individual compounds, and their efficiency, I would like to briefly refer to an article entitled, "A Practitioner's Experience in the Diagnosis and Control of Parasitic Gastro-Enteritis in Imported Steers" presented by Dr. Harry R. Green at the 32nd Annual Conference for Veterinarians, New York State Veterinary College, Cornell University, January 1940. In reporting on three outbreaks of parasitism in feeder steers brought into New York, two of which apparently were primarily due to

Ostertagia and/or *Cooperia* and one of *Haemonchus*, he states therapy consisted of the administration of 100 cc of a 1 percent solution of copper sulfate and nicotine sulfate per 100 lbs. of body weight. One week later, 40 cc of equal parts tetrachlorethylene and mineral oil were given immediately following the application of 2-3 cc of 4% copper sulfate in the throat. Dr. Green's comment relative to the first herd and presumably applicable to the others was, "These animals improved so rapidly that in one month from the first treatment I could hardly believe that they were the same animals."

In USDA circular No. 614 published in January 1942, entitled "Internal Parasites of Cattle," we find the following drugs recommended for those parasites which we have listed as important: Stomach and intestinal worms: Tetrachlorethylene, Copper sulfate, CuNic solution, and Phenothiazine; Lungworms — no treatment; Liver flukes — Carbon Tetrachloride, and Hexachlorethane.

In making reference to these rather ancient publications, I have two purposes. First, to point out that practical use of a compound may produce gratifying results even though scientific efficiency data obtained in laboratory tests may not indicate that such should occur. Secondly, I want to point out that the revolution which has occurred in the therapy of nematode parasites is quite recent and that such a revolution is just beginning in the therapy of trematodes. Such a revolution has yet to begin insofar as the Cestodes or tapeworms are concerned. This report is limited to those anthelmintics for use against the nematodes.

In order to dispose of the more historical nematocidal compounds, namely, Copper sulfate, CuNic Solution, and Tetrachlorethylene, I believe the following statement to be sufficiently accurate. There have been very few controlled or critical tests conducted with these materials in cattle and to some extent those that have been reported do not uniformly confirm one another. Where significant activity does occur it is largely confined to those species inhabiting the abomasum.

From a philosophical standpoint, I believe we can consider the revolution in anthelmintic development to have begun in the late 1940's or early 1950's. It was at this time that extensive use of controlled and critical tests by parasitologists in most parts of the world occurred. As a result of this type of test, more attention was given to the action of a given chemical against a given species of parasite. At this time, as well as during the previous decade, phenothiazine was the general all purpose anthelmintic. It retained this position until the early 1960's when its pre-eminence was replaced by thiabendazole.

If we are to compare efficiency of currently available anthelmintics it is necessary first to establish some basis of comparison. For the purposes of this presentation such a basis is presented in Table 5. It should be noted that this

TABLE 5

A RATING SYSTEM FOR GENERAL EVALUATION OF ANTHELMINTICS

Rating	Efficiency
1	90-100% Removal – in all instances
2	90-100% Removal – notable exceptions
3	80-90% Removal
4	60-80% Removal
5	40-60% Removal
6	< 40% Removal

grading system as used in this report applies only to mature (adult) parasites. Further, it should be noted that this grading system applies only to "parasitological efficiency" and is not intended to infer direct correlation with performance of treated cattle in all instances.

It is only fitting that we begin our discussion of individual compounds with *phenothiazine.* This compound has been praised and damned as an anthelmintic by practitioners, farmers, and researchers alike. I believe much of the damnation has resulted from instances where the condition was due to inadequate diagnosis, i.e., disease primarily due to species tolerant to phenothiazine, to improper dosage, to poor quality drug and perhaps to the development of resistant strains of previously susceptible species. This latter condition has never been demonstrated in cattle, although it has been well documented in sheep.

Limited numbers of critical tests as early as 1940 and continuing into the 1950's indicated that in cattle phenothiazine was never dependable against species other than *Haemonchus contortus (H. placei)*, *Trichostrongylus axei*, and *Oesophagostomum radiatum.*

Table 6 presents an evaluation of phenothiazine efficiency. In this table as in all similar tables to follow, the vertical line between ratings of 3 and 4 separates acceptable activity (ratings of 1, 2, and 3) from unacceptable activity (ratings of 4, 5, and 6). Where variable results can be regularly expected, the extent of the variation is indicated by a horizontal line between the appropriate ratings.

As noted in Table 5, phenothiazine still deserves consideration as an anthelmintic in those instances where *Haemonchus sp.*, *T. axei*, and *O. radiatum* are the primary parasites of the gastrointestinal tract. Disadvantages of this anthelmintic are the allergenic effects insofar as the administrator of the material may be concerned, a relatively low

TABLE 6

EFFICACY OF PHENOTHIAZINE IN CATTLE

Helminth	Rating 1	2	3	4	5	6
Abomasum						
Haemonchus	X					
Ostertagia		X	—	—	X	
Trichostrongylus	X					
Small Intestine						
Cooperia			X	—	—	X
Trichostrongylus		X	—	—	—	X
Bunostomum		X	—	—	—	X
Large Intestine						
Oesophagostomum	X					
Lungs						
Dictyocaulus						X

therapeutic index, volume of the dosage required in larger animals, and the rather narrow spectrum of dependable activity.

Thiabendazole (TBZ) was first introduced into the United States as an anthelmintic for use in sheep. To the surprise of none, it was also used in cattle, but not with F. & D.A. sanction until sometime later.

Table 7 presents the anthelmintic efficiency ratings of TBZ at a dosage level of 5 gms/100 lbs.

TABLE 7

EFFICIENCY OF THIABENDAZOLE IN CATTLE

Helminth	Rating (5 gms/100 lbs.) 1	2	3	4	5	6
Abomasum						
Haemonchus	X					
Ostertagia	X					
Trichostrongylus	X					
Small Intestine						
Cooperia		X	X			
Trichostrongylus	X					
Bunostomum		X	—	X		
Large Intestine						
Oesophagostomum		X				
Lungs						
Dictyocaulus					X	X

body weight. Examination of the table indicates that TBZ enjoys a much wider spectrum of activity than does phenothiazine. The writer has never been satisfied with the dosage recommendation prescribed for cattle. A prophylactic dosage of 3 gms/100 lbs. (66 mg/kg), and a therapeutic dosage of 5 gms/100 lbs. (111 mg/kg), the latter to be used in all instances where *Cooperia sp.* is of primary importance are recommended. In my opinion, what is now very often considered therapeutic use was previously considered prophylactic, and I am not at all sure that practitioners or ranchers can be certain in all instances which condition is present and in particular whether or not *Cooperia sp.* is a primary factor. It is my belief, and *I cannot prove it*, that 3 gm/100 lbs. in smaller cattle is inadequate and 5 gm/100 lbs. in larger cattle is excessive. It is my opinion that both TBZ and Phenothiazine have a minimal and maximal dosage range. Further, of all measurable parameters I believe that of the gastrointestinal volume is best correlated with this minimal-maximal dosage range.

Anatomists have indicated to the writer that the volume of this tract is essentially constant after a growing animal reaches a body weight of 700 to 800 lbs. Limited data from phenothiazine and TBZ studies in cattle suggests increasing total dosages according to body weight above this point does not result in increased anthelmintic efficiency. In simple terms, equal efficiencies might be obtained at 5 gm/100 lbs in a 300 lb. animal and at 3 gm (or less)/100 lbs. in an 800 lb. steer. Unfortunately, this rather important aspect of efficiency versus cost, and ease of administration, has not been studied in depth.

The most obvious advantages of TBZ are: 1) the broad spectrum of activity, 2) the low toxicity and, 3) the multiplicity of available dosage forms. Disadvantages are: 1) its cost, although where anthelmintics are needed extensive data has been obtained to justify the expense, and 2) the relatively large volume of drench suspension required in larger animals.

A more recent anthelmintic introduced in the U.S.A. is the levo isomer of *Tetramisole* which has been given the name of *levamisole* (1-TTZ). Tetramisole as originally marketed in many countries was composed of essentially equal amounts of the dextro and levo isomers. Research at American Cyanamid and Company revealed that while both isomers contributed equally to toxicity in the host animals, essentially all anthelmintic activity was contained in the levo isomer. As a result it was possible to double the therapeutic index. It is my belief that a misunderstanding of this factor may have contributed to some of the rumors which have reached the writer relative to the potential toxicity of this anthelmintic as compared to others. Dosage recommendations with this material include the range of 4-8 mg/kg. The minimal toxic dose approximates 40 mg/kg. Thus at the maximum recommended dose the minimal toxic dose is five times the therapeutic dose and at the minimal recommended dose it is ten times the therapeutic dose. From the writer's point of view, this removes toxicity as a factor in discriminating against this material.

Levamisole is soluble in water and as such has the potential for greater versatility insofar as administration is concerned. Since it is highly soluble and the therapeutic dose is small, relatively small volumes of drench solutions can be administered. By the same token, if carelessly handled, this may be a disadvantage in that small errors in dosing, regurgitation, misuse of drench gun, etc. may result in inadequate dosage. The anthelmintic spectrum of levamisole in cattle is presented in Table 8.

TABLE 8

EFFICIENCY OF l-TETRAMISOLE (LEVAMISOLE) IN CATTLE

Helminth	Rating 1	2	3	4	5	6
Abomasum						
Haemonchus	X					
Ostertagia	X					
Trichostrongylus		X				
Small Intestine						
Cooperia	X					
Trichostrongylus	X					
Bunostomum	X					
Large Intestine						
Oesophagostomum	X					
Lungs						
Dictyocaulus		X				

It is noted that the anthelmintic spectrum of levamisole is quite broad and it is the only broad spectrum anthelmintic approved for use against the lungworm *Dictyocaulus vivipara*. Of those species listed as of economic importance the only one of questionable status at this time is that of *Trichostrongylus axei*. Colorado workers using experimental infections in calves (controlled trials) obtained mean efficiencies at 4 mg/kg and 8 mg/kg respectfully of 27 and 26% with drench material. With 1.5% levamisole pellets efficiencies of 60 and 52% were obtained at the same dosage rates. South Carolina workers obtained 70% reduction at 4 mg/kg although at 8 mg/kg an efficiency of 96% was obtained. Georgia workers with a drench of 8 mg/kg obtained a mean reduction of 87.1% while with a bolus preparation at 5.4 mg/kg a mean efficiency of 80.5% was obtained. Other workers, including those in California, have obtained efficiencies of 90% or more against *T. axei* at 8 gm/kg body weight. It is quite possible that when more results from additional tests are reported other genera and species will be found in which the ratings in Table 7 may be less favorable. Without attempting to account for the variation in results against *T. axei*, it is the writer's opinion that if one elects to use levamisole in cattle where *T. axei* is a primary factor, the maximal recommended dosage of 8 mg/kg should be used.

The definable attributes of this compound are its broad spectrum, its relative safety, the small quantity (total volume) required for administration of therapeutic dosage, and its water solubility which allows a wider, but yet undeveloped potential for administration. In addition, levamisole is active when administered parenterally and if suitable formulation can be devised this attribute may be of considerable value. Disadvantages, if they may be so termed, would be the relatively high cost and the yet to be determined consistency against *T. axei*.

Haloxon, a recent addition to the list of anthelmintics for cattle, is an organo-phosphate rather closely related to coumaphos. The spectrum of activity is presented in Table 9. It is noted that the spectrum of acceptable activity is confined to species of trichostrongylids inhabiting the abomasum and small intestine. Indeed, this material is registered only for use against *Haemonchus*, *Trichostrongylus*, *Ostertagia*, *Cooperia* and *Strongyloides*. The latter genus, i.e. *Strongyloides*, is only rarely if ever of economic importance in cattle. With this chemical there is some variability against *Ostertagia ostertagi* although it would be expected that acceptable efficiency (80% or higher) should be obtained. This material when used as directed is quite safe and the minimal toxic dose is some six to eight times the recommended therapeutic dose. Other than price, haloxon does not appear to have outstanding advantages over thiabendazole or levamisole. In fact, the more limited spectrum might lead to prejudice against it. As previously pointed out, however, where proper diagnosis is carried out, and the target species are susceptible, or where ecological factors, as in large portions of California limits the helminth fauna to susceptible species this compound might well be the drug of choice.

TABLE 9

EFFICIENCY OF HALOXON (50 mg/kg) IN CATTLE

Helminth	Rating 1	2	3	4	5	6
Abomasum						
Haemonchus	X					
Ostertagia		X				
Trichostrongylus	X					
Small Intestine						
Cooperia	X					
Trichostrongylus	X					
Bunostomum						X
Large Intestine						
Oesophagostomum		X ———	———	X		
Lungs						
Dictyocaulus						X

Coumaphos, an organophosphate long used as a systemic insecticide (Co-Ral), has for many years been known to possess anthelmintic activity when administered orally. Unfortunately, the single therapeutic dose closely approximates the minimal toxic dose, and in some instances exceeds it! In studies relative to the control of fecal breeding flies by continuous feeding of low level (1.25-2.0 mg/kg/day) amounts of coumaphos, it was found that after a period of some six days a significant anthelmintic action had occurred. As would be expected, this spectrum of activity was quite similar to that of haloxon. Table 10 presents the writer's evaluation of this activity when coumaphos is fed at 2 mg/kg body weight for six days.

TABLE 10
EFFICIENCY OF COUMAPHOS
(2 mg/kg for 6 days) IN CATTLE

Helminth	Rating 1	2	3	4	5	6
Abomasum						
Haemonchus	X					
Ostertagia		X				
Trichostrongylus		X				
Small Intestine						
Cooperia	X					
Trichostrongylus		X				
Bunostomum						X
Large Intestine						
Oesophagostomum						
Lungs						
Dictyocaulus						X

Coumaphos, which is to be marketed as a premix under the trade name of Baymix by Chemagro Corporation, is registered for use against *Haemonchus*, *Ostertagia*, *Trichostrongylus*, *Cooperia*, and *Nematodirus*. All of these genera are trichostrongylid nematodes inhabiting the abomasum and/or small intestine. For controlling these helminths, the premix is to be added to rations or supplements for a six day period at a daily dosage of 2 mg/kg of body weight.

Advantages of this material is its cumulative effect which allows its application under certain circumstances to cattle on pastures or rangelands without the problems attendant with restraint. All the other anthelmintics considered in the report appear to be effective only when administered as a single therapeutic dose or when consumed in food or water over a relatively short period (one day or less). It is possible that the closely related haloxon may possess this same characteristic, however, the writer is unaware of research data pertinent to this.

The most obvious disadvantage is the fact it is to be marketed only as a premix which limits the potential applications to which an enterprising and innovative veterinarian might use it.

Ruelene, another organophosphate which has long been used as a systemic insecticide, has also been known to have anthelmintic action when administered orally. Attempts to develop it as an anthelmintic in drench formulation have not met with a great deal of success, apparently as a result of problems in toxicity.

A discussion of ruelene is incorporated in this report as an example of the anthelmintic efficacy of spray or pour-on systemic insecticides. Table 11

TABLE 11

EFFICIENCY OF RUELENE POUR-ON IN CATTLE

Helminth	Rating 1	2	3	4	5	6
Abomasum						
Haemonchus	X	—	—	—	X	
Ostertagia				X	—	X
Trichostrongylus					X	X
Small Intestine						
Cooperia				X	—	X
Trichostrongylus						
Bunostomum						
Large Intestine						
Oesophagostomum			X	—	—	X
Lungs						
Dictyocaulus						X

presents an evaluation of the anthelmintic efficiency as obtained in controlled trials. It is noted that only with the genera *Haemonchus* and *Oesophagostomum* can one at any time expect activity in excess of 60-80%. Further, even when these two genera are considered, the efficiency can be anticipated to be much lower than the acceptable level. In the opinion of the writer, any claims made relative to the dual action (insecticidal and anthelmintic) of this and other topically applied systemic insecticides are unwarranted. This, of course, does not imply that they may not be of value in certain circumstances as previously alluded to in this report.

For summation purposes, Table 12 presents the spectrum of acceptable anthelmintic efficiency of individual chemicals against the economically important species of nematodes in cattle. In addition to those chemo-therapeutic compounds discussed, one additional anthelmintic, *Dictycide*, is listed in Table 11. This compound has acceptable anthelmintic activity only against adult (mature) stages of the lungworm, *Dictyocaulus vivipara*.

TABLE 12
SPECTRUMS OF ACCEPTABLE ANTHELMINTIC ACTION

Helminth	Pheno-thiazine	Thiabendazole 3 gm/100 lbs. (TBZ-3)	Thiabendazole 5 gm/100 lbs. (TBZ-5)	Levamisole (1-TTZ)	Coumaphos	Haloxon	Dicty-cide
Abomasum							
Haemonchus	X	X	X	X	X	X	
Ostertagia		X	X	X	X	X	
Trichostrongylus	X	X	X	X	X	X	
Small Intestine							
Cooperia			X	X	X	X	
Trichostrongylus		X	X	X	X	X	
Bunostomum			X	X			
Large Intestine							
Oesophagostomum	X		X	X			
Lungs							
Dictyocaulus				X			X